

# CCRI - Coral Reef Long-Term Ecological Monitoring Program: A proposal and case studies from the eastern Puerto Rican shelf.

- **Edwin A. Hernandez**

- University of Puerto Rico
- Department of Biology

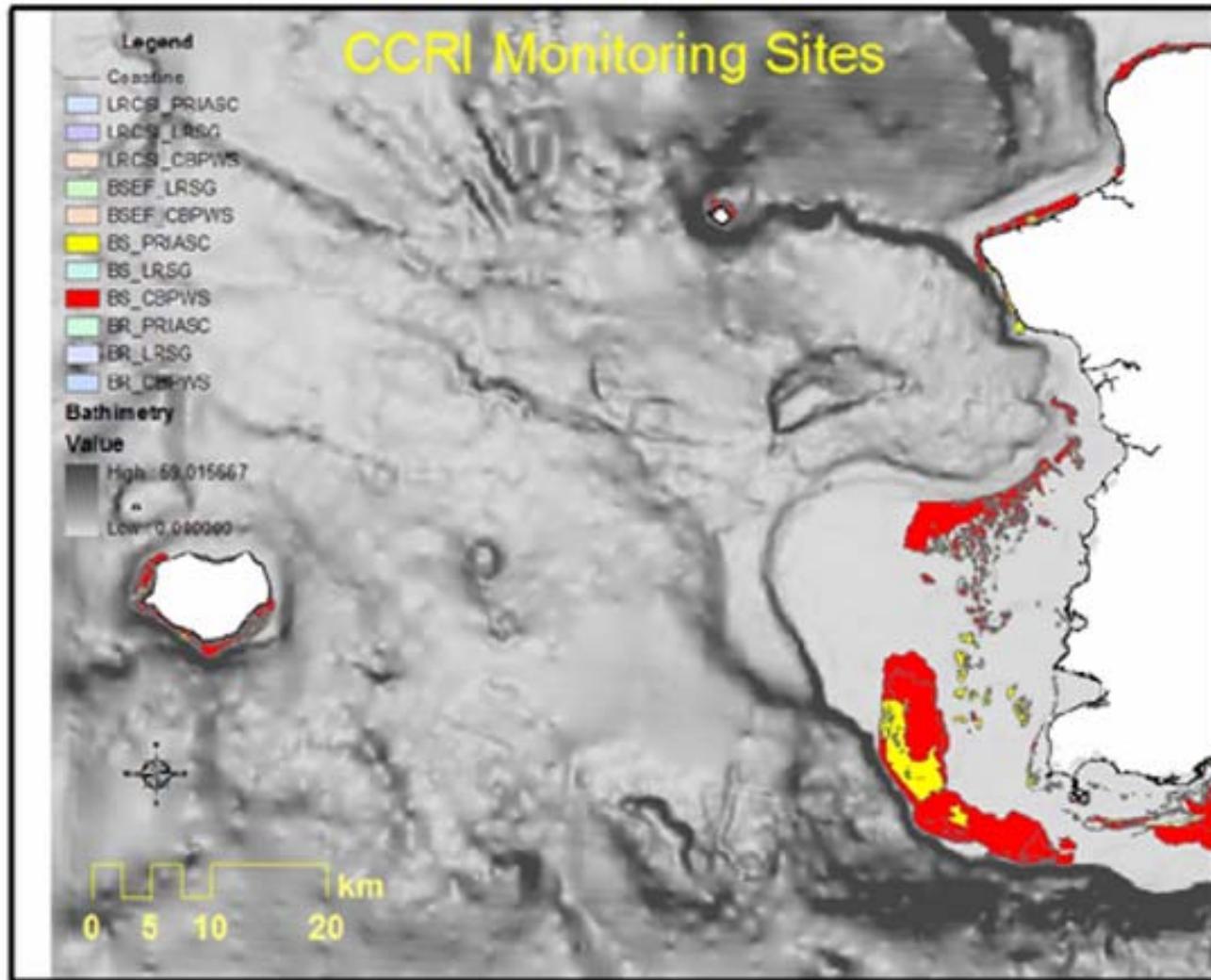
Coral Reef Research Group

[coral\\_giac@yahoo.com](mailto:coral_giac@yahoo.com)

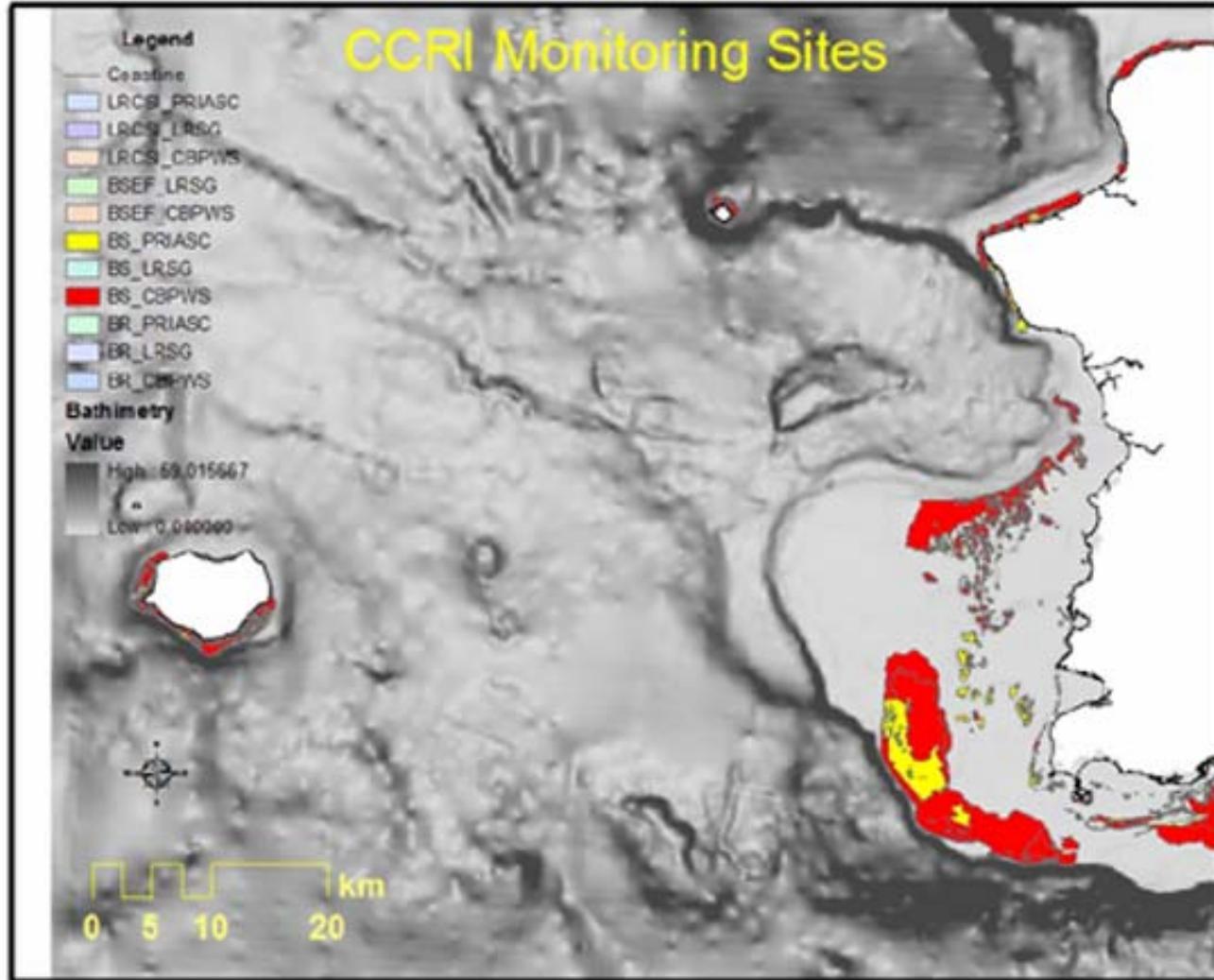


# Objectives

- Discuss the proposed sampling design for establishing the CCRI - Coral Reef Long-Term Ecological Monitoring Program (CRLTEMP).
- Present three case studies from the eastern PR shelf as examples of the type of analysis that will be carried out in the CRLTEMP.



Mayaguez (Tourmaline, Ron, Media Luna)  
Boqueron (El Palo, Resuellos, Gallardo)



Mona (Pajaros, Mujeres, Carmelitas)  
Desecheo (North, Botes, Canoas)

# CCRI-CRLTEMP Research questions

- What are spatial and temporal variation patterns in the community structure of coral reef benthic and fish communities across the western PR shelf?
- Are coral reef benthic and fish communities in oceanic islands (Mona, Desecheo) in “better” ecological condition than those located in the western PR shelf (Boqueron, Mayaguez)?

# Fish community assessment

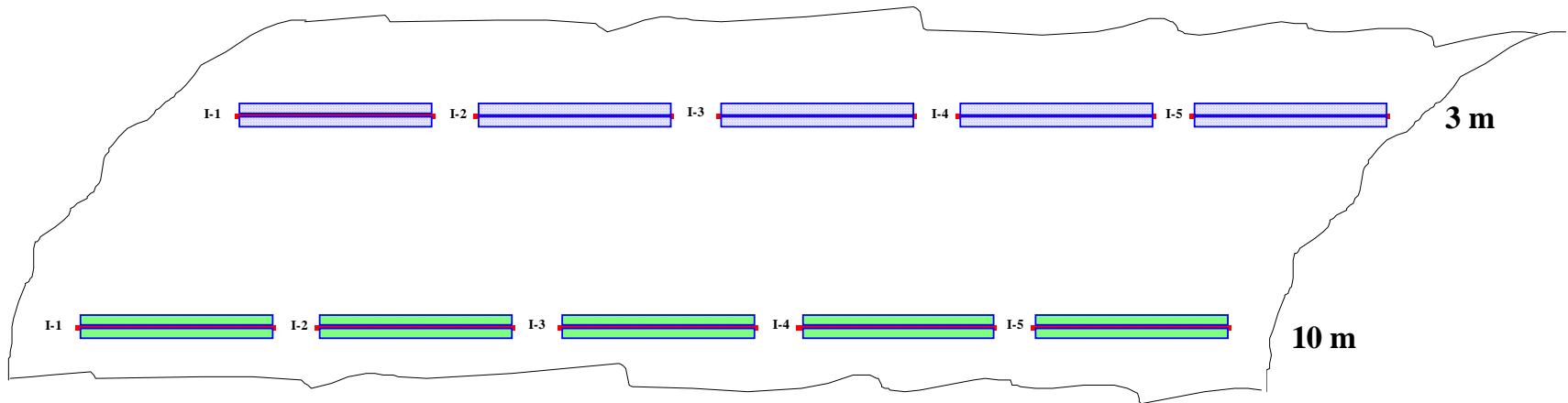
- Belt transects (25 x 4 m).
- 4-way ANOVA
  - Location (shelf, oceanic)
  - Site (n=2)
  - Reef (n=3)
  - Depth (3 m, 10 m)
  - Transect (n=6) – error term



# Fish community data

- Species richness.
- H'n.
- J'n.
- Abundance.
  - Total.
  - Species.
  - Functional groups.
  - Fishery target species.
- Biomass.
  - Total.
  - Species.
  - Functional groups.
  - Fishery target species.

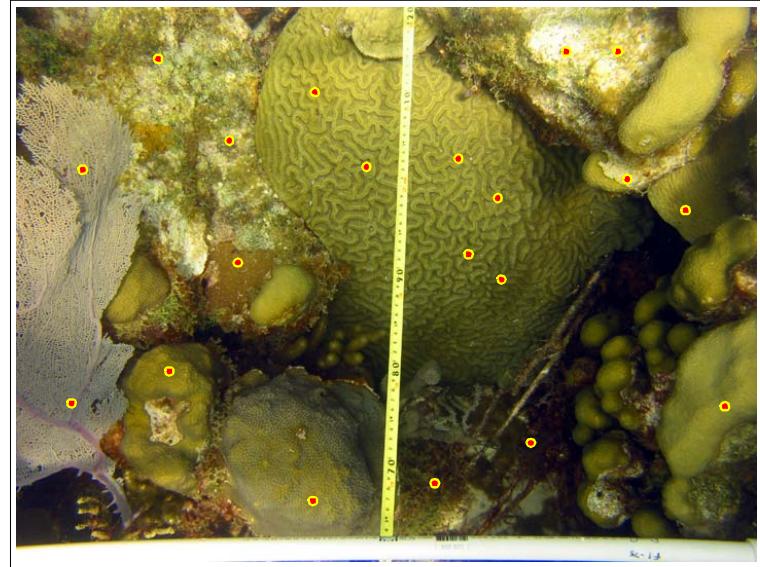
# Benthic community assessment



- Belt transects (10 x 2 m).
- 3-way ANOVA
  - Location (n=2); Site (n=2); Reef (n=3); Depth (n=2)
  - Transect (n=5) – error term

# Benthic community data collection

- High-resolution digital photography.
- Quadrats 1 m<sup>2</sup> (n=20/transect).
- 50 random dot grids (CPCE 3.0, NSU).



# Benthic community data

- Coral species richness.
- Colony abundance.
- H'n
- J'n.
- % Coral.
  - Scleractinians.
  - Hydrocorals.
  - Encrusting octocorals.
- % Recent/Old mortality.
- % Algae (total).
  - Macroalgae.
  - Filamentous.
  - Halimeda.
  - Erect calcareous algae.
  - Encrusting algae.
- % Cyanobacteria.
- % Sponges.
- % Didemnid tunicates.
- % Others.

# Benthic community data

- Gather baseline information regarding the incidence of coral diseases/syndromes.
- Follow Weil (2002).
- Belt transects (10 x 2 m).



# Benthic community data

- Assess benthic macroinvertebrate densities.
- Belt transects (10 x 2 m).
  - *D. antillarum*.
  - *C. abbreviata*.
  - *H. carunculata*.



# Expected end-products

- Publish, of course!!!
- Produce useful data analysis and interpretation that can be readily available for.
  - Managers.
  - Decision-makers.
  - General public.
- Training of DNER personnel to apply the CCRI-CRLTEMP model to other locations.

# Case Study #1

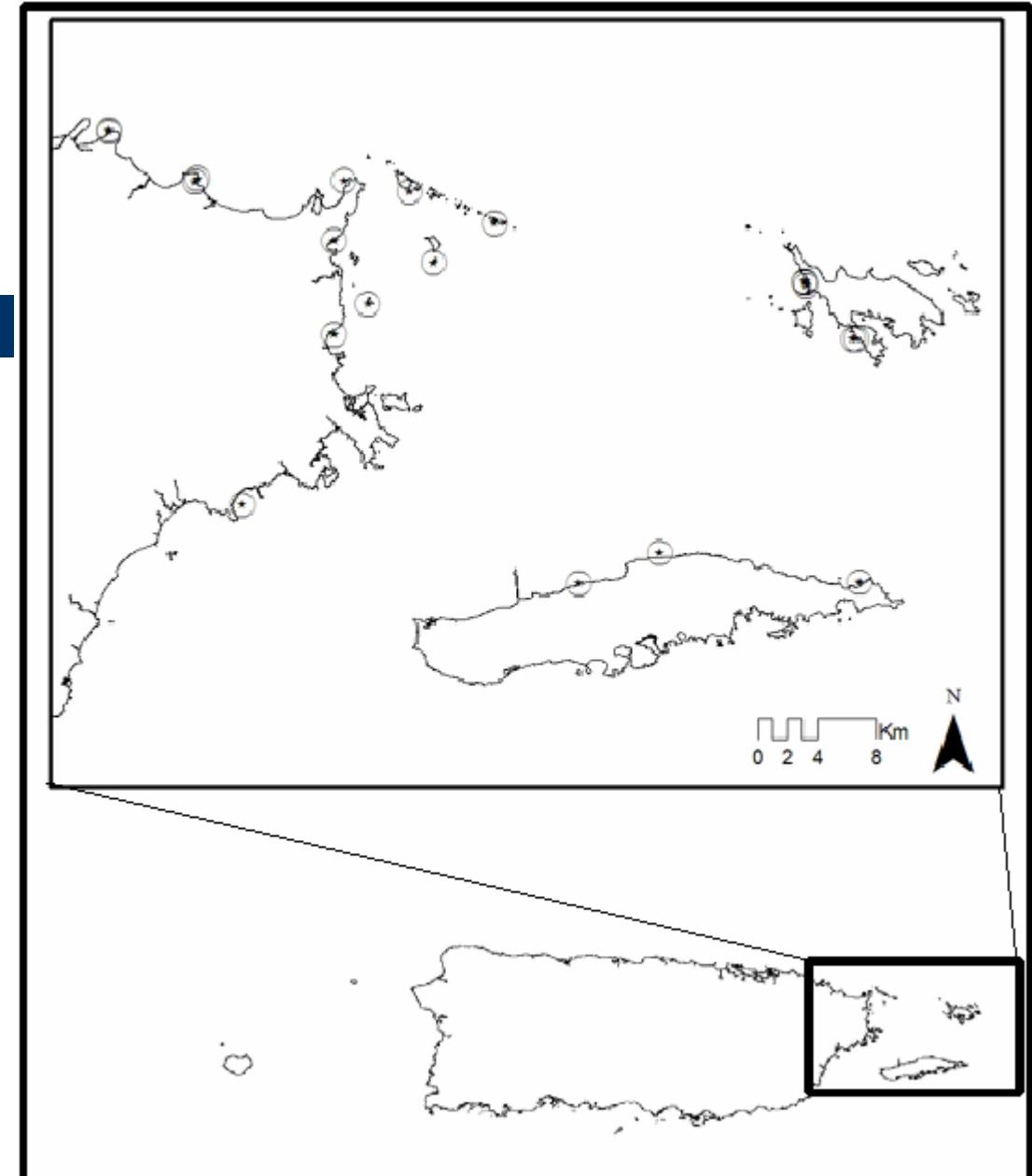
- Spatial variation patterns in coral reef community structure in the eastern PR shelf.

# Design

20 Sites

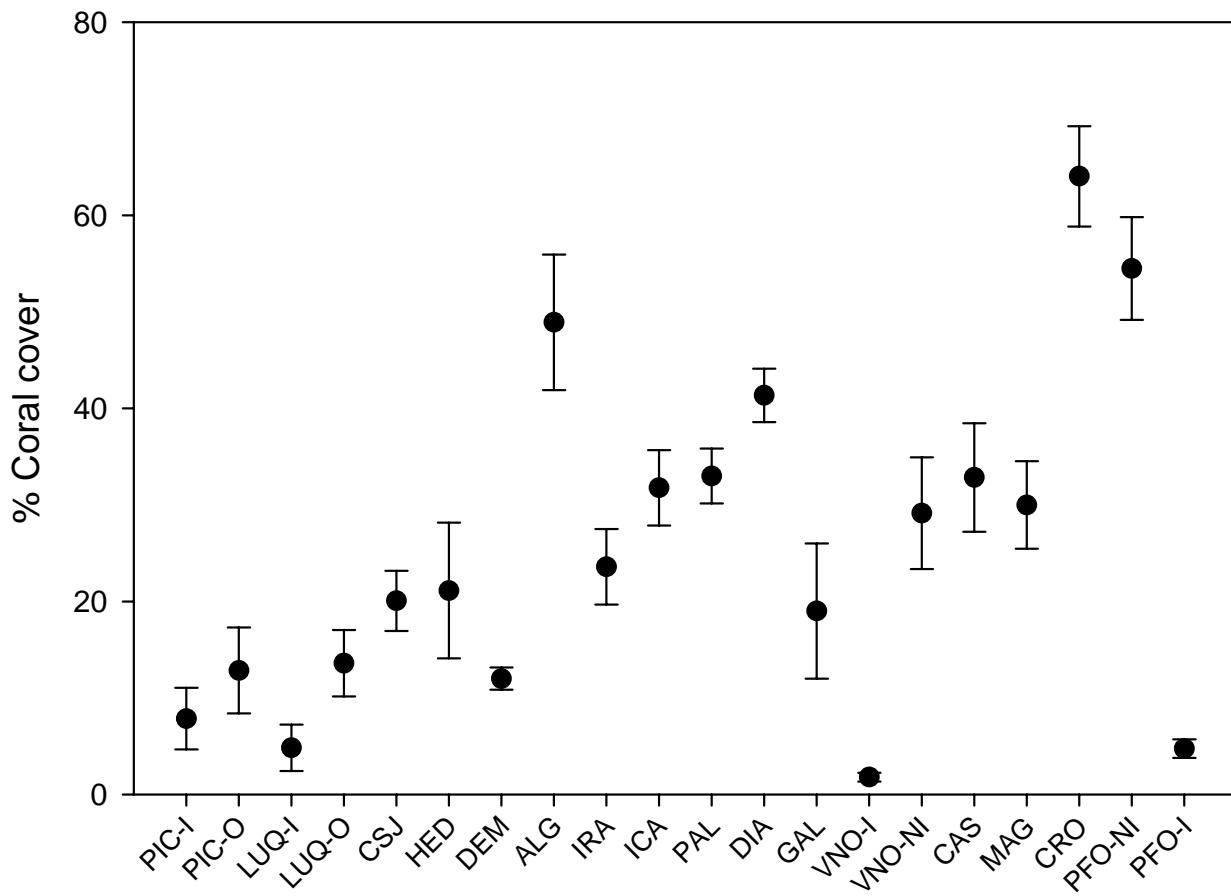
Depth: 3-12 m

Replicates: 6-11  
transects/site  
(N=131 transects)



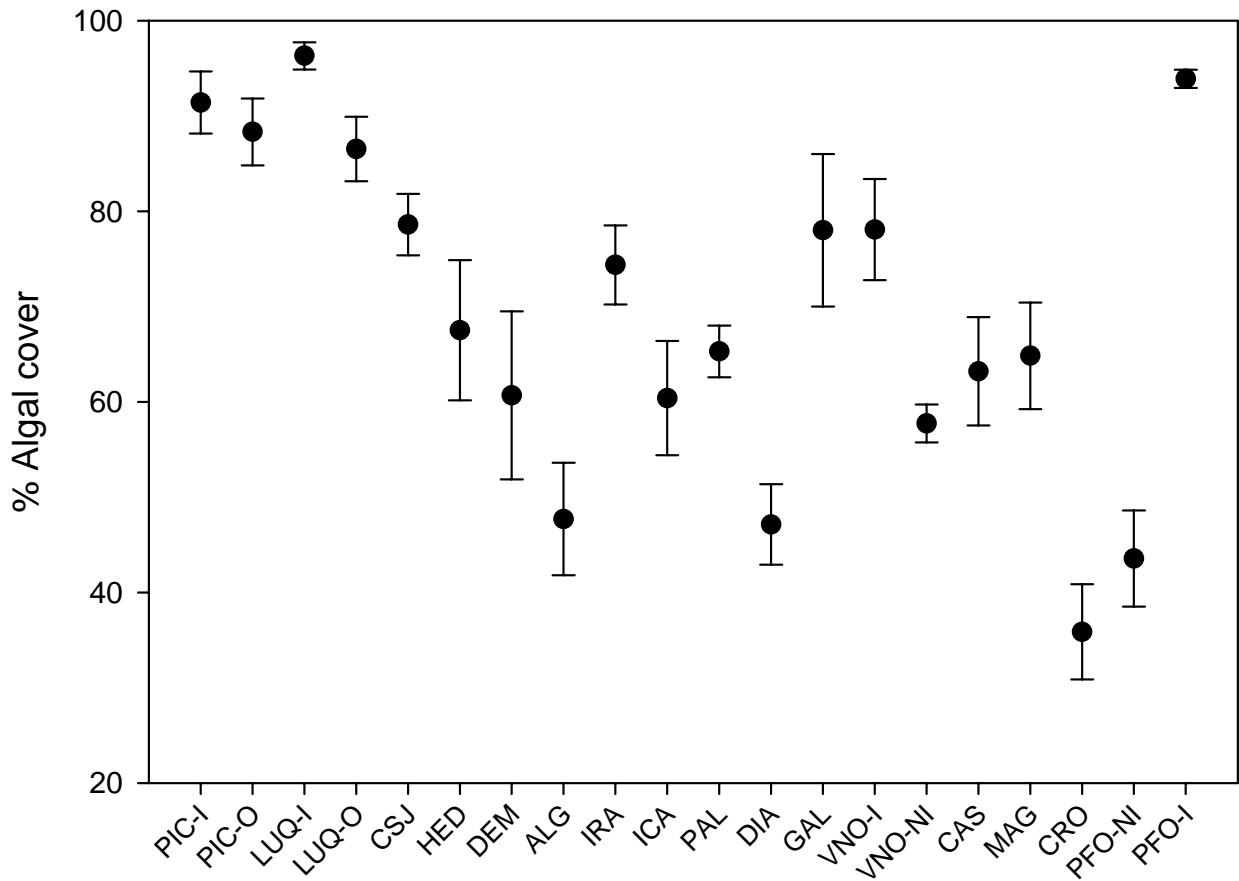
# Low % Coral

## Chronic degradation and bombarded reefs

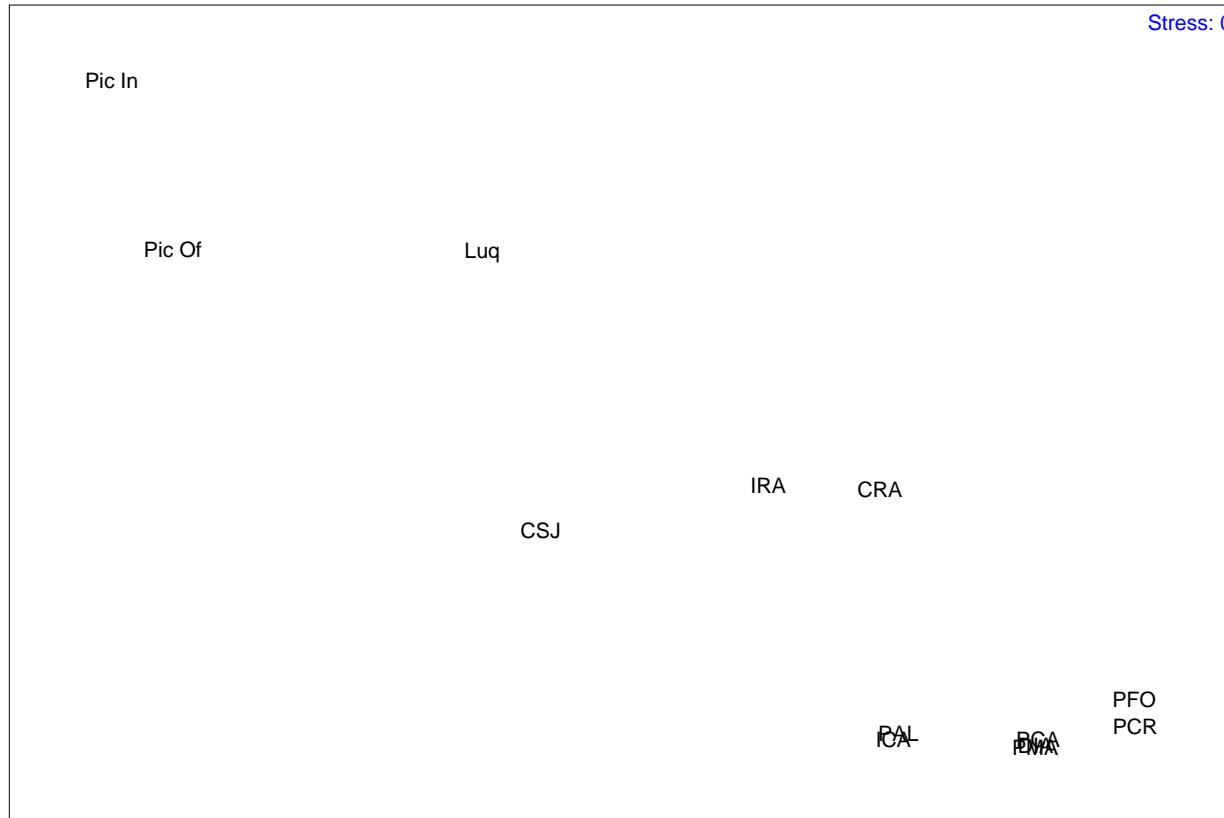


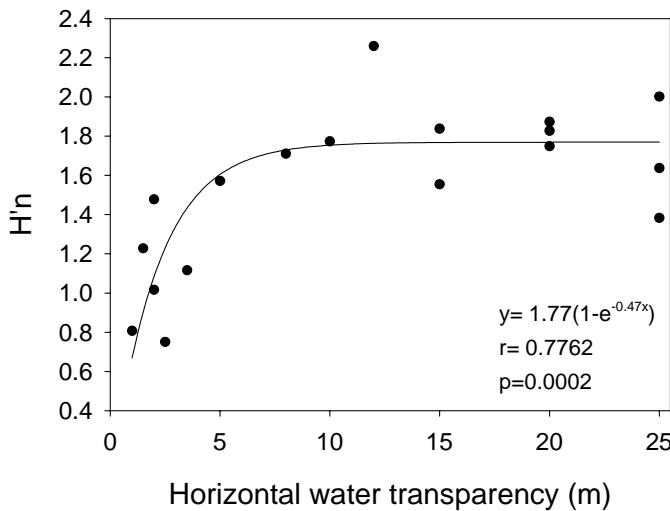
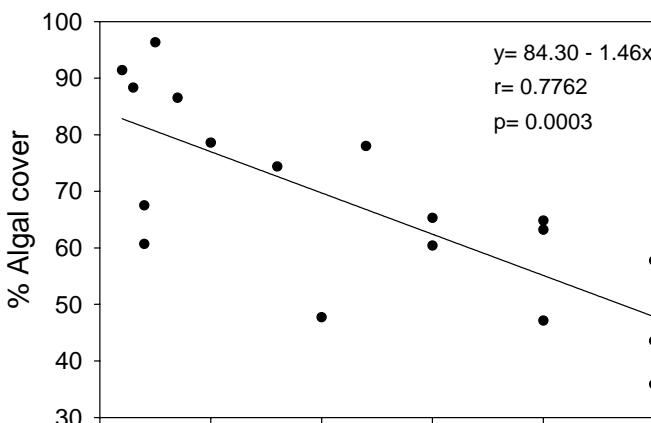
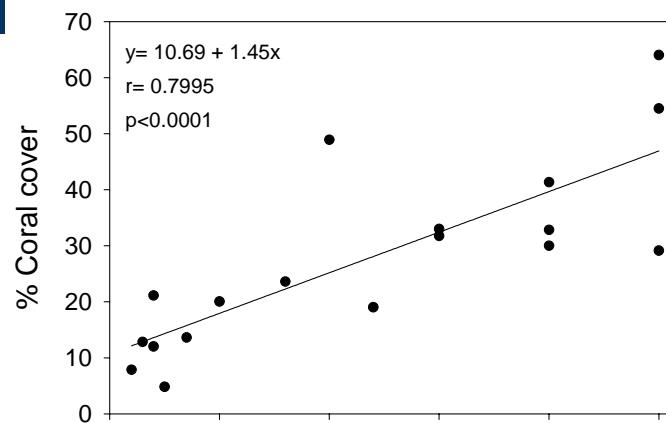
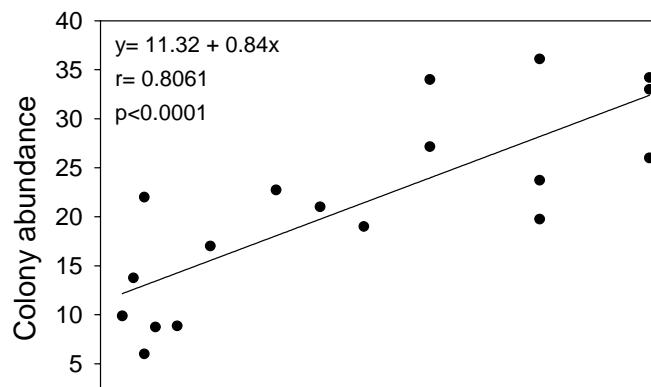
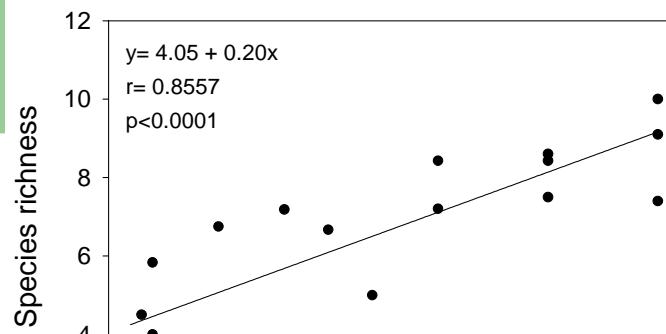
# High % Algae

## Chronic degradation and bombarded reefs



# MDS Plot: Secchi readings





**TABLE 1.** One-way ANOVA testing the effects of different variables.

| Factor                        | Site <sup>a</sup> | Treatment   | Management Level | Reef category |
|-------------------------------|-------------------|-------------|------------------|---------------|
| Species richness              | <0.0001           | 0.0324      | 0.2090 (NS)      | 0.1161 (NS)   |
| Colony abundance              | <0.0001           | 0.0200      | 0.0407           | 0.1174 (NS)   |
| % Coral cover                 | <0.0001           | 0.0291      | 0.1022 (NS)      | 0.1271 (NS)   |
| % Algal cover                 | <0.0001           | 0.0534 (NS) | 0.3295 (NS)      | 0.1328 (NS)   |
| % Sponge cover                | <0.0001           | 0.8906 (NS) | 0.1337 (NS)      | 0.4479 (NS)   |
| % Zoanthid cover <sup>c</sup> | <0.0001           | 0.5329 (NS) | 0.1399 (NS)      | 0.2211 (NS)   |
| H'n                           | <0.0001           | 0.0182      | 0.7109 (NS)      | 0.1379 (NS)   |
| J'n                           | <0.0001           | 0.3365 (NS) | 0.7335 (NS)      | 0.0062        |
| Water transparency            | <0.0001           | <0.0001     | 0.5876 (NS)      | 0.0132        |

<sup>a</sup>DF= degrees of freedom (between,within): site (19,112), treatment (3,18), management level (1,18), reef category (2,17).

**TABLE 2.** Significant differences in the coral reef community structure spatial patterns.

| Factor   | Global R statistic | Significance (p)   |
|--|--------------------|--------------------|
| <b>One-way ANOSIM test<sup>a</sup></b>         |                    |                    |
| Sites  | <b>0.649</b>       | <0.0001            |
| Treatment <sup>b</sup>                         | <b>0.329</b>       | <b>0.0040</b>      |
| Management <sup>c</sup>                        | <b>0.105</b>       | <b>0.1060 (NS)</b> |
| Reef category                                  | <b>0.515</b>       | <0.0001            |
| <b>Two-way crossed ANOSIM test<sup>a</sup></b> |                    |                    |
| Sites x Treatment                              | <b>0.497</b>       | <0.0001            |
| Sites x Management                             | <b>0.625</b>       | <0.0001            |
| Sites x Reef category                          | <b>0.534</b>       | <0.0001            |
| Treatment x Management                         | <b>0.630</b>       | <b>0.0380</b>      |
| Treatment x Reef category                      | <b>0.281</b>       | <b>0.0660 (NS)</b> |
| Management x Reef category                     | <b>0.083</b>       | <b>0.4000 (NS)</b> |

<sup>a</sup>ANOSIM tests based on 5,000 permutations. Data were square root-

transformed. <sup>b</sup>Treatments (horizontal water transparency categories): I= <5 m, II= 5-15 m, III= >15 m, IV= Bombarded reefs.

<sup>c</sup>Management level: R=Natural Reserve sites, NR= Non-Natural Reserve control sites.

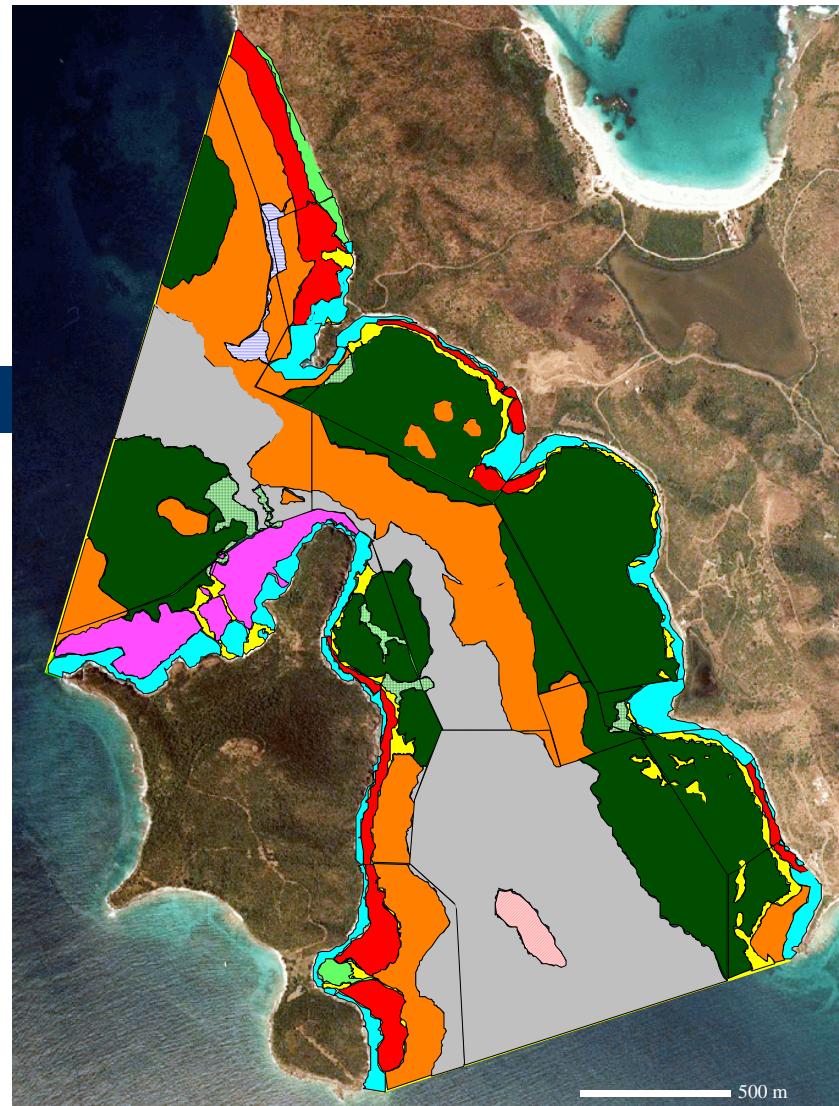
## Case Study #2

- LPCNR Coral Reef Long-Term Ecological Monitoring Program.

# Luis Pena Channel No-Take Natural Reserve, Culebra Island

June 11, 1999  
Sept. 30, 1999 (no-take)

637 ha



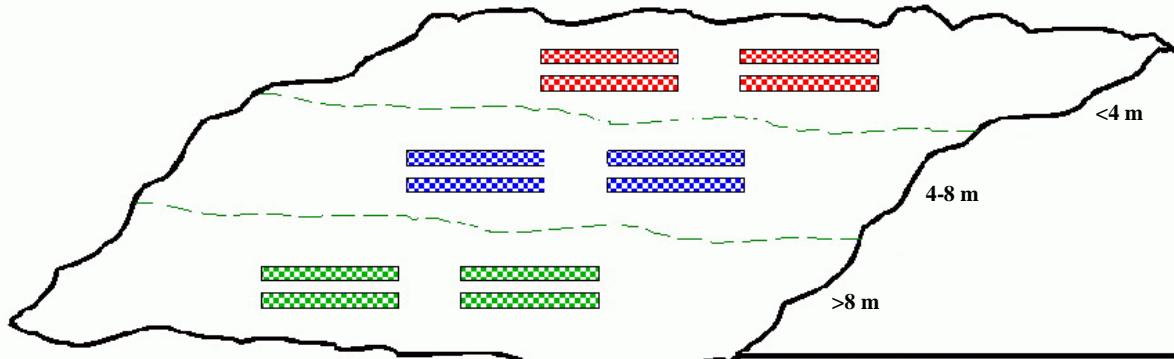
- Arrecife linear con algunos surcos y espolones
- Arrecife/Rocas colonizadas
- Arrecife/Pavimento colonizado
- Arrecife/Pavimento colonizado con canales
- Arrecife/Rocas y corales dispersos
- Arrecife de parche (corales agregados)

- Planicie de Macroalgas (10-50%)
- Hierbas marinas (Continuas)
- Hierbas marinas (70-90%)
- Hierbas marinas (30-50%)
- Arena

# Bombs, bombs and more bombs!

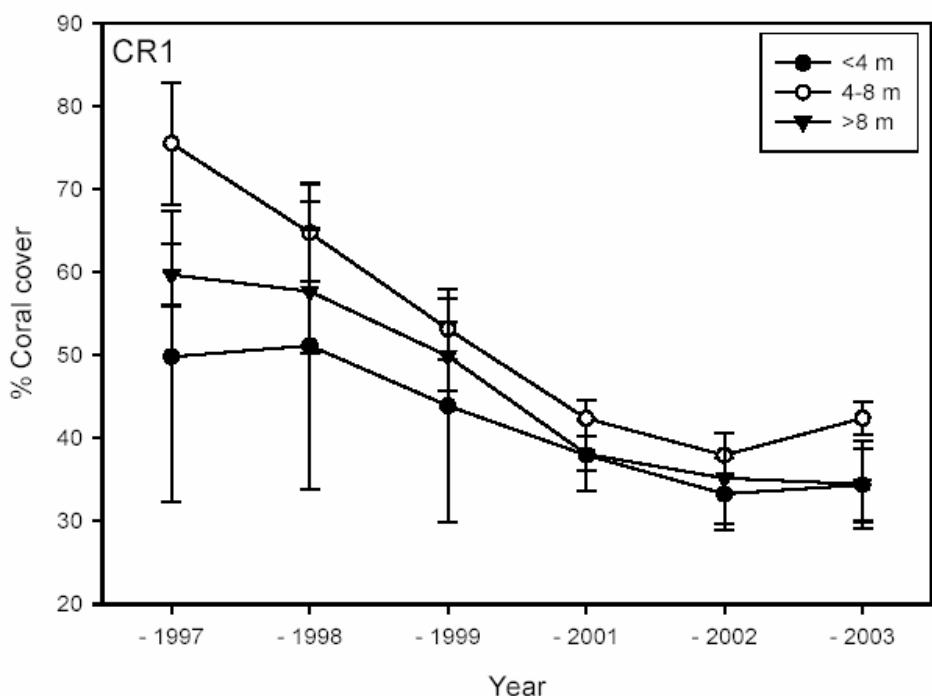


# Methods



Line intercept transects + digital photography (10 m-long).  
2-way Repeated Measures ANOVA  
Years (1997, 1998, 1999, 2001, 2002, 2003)  
Depth (<4m; 4-8 m; >8 m)

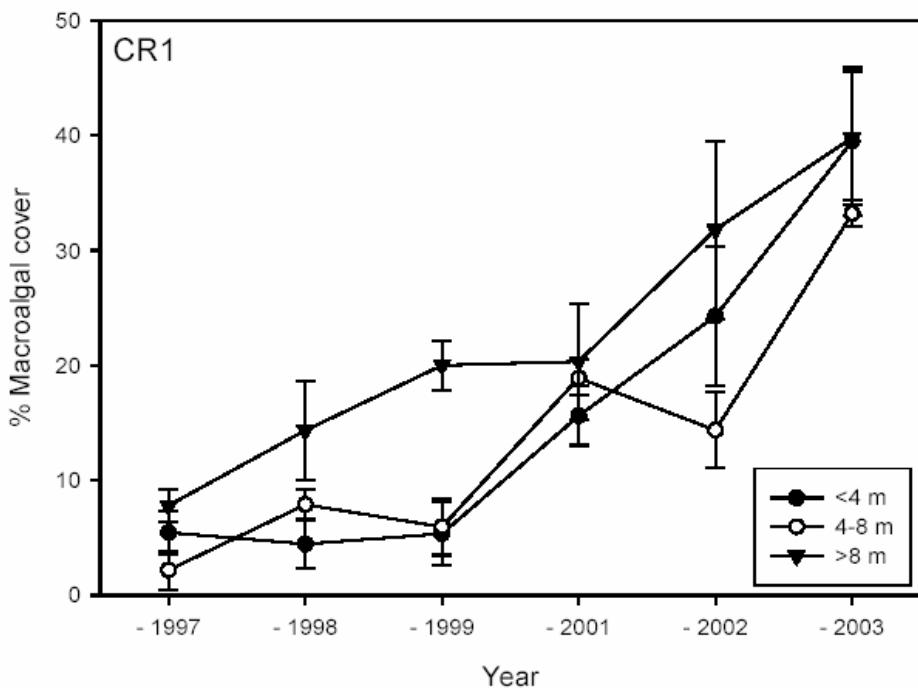
# Reefs are rapidly declining!



- 31-66% decline in % coral cover.
- 5-11% annual decline.

FIGURE 7. Change in the % of living coral cover at CR1 (mean $\pm$ one standard error).

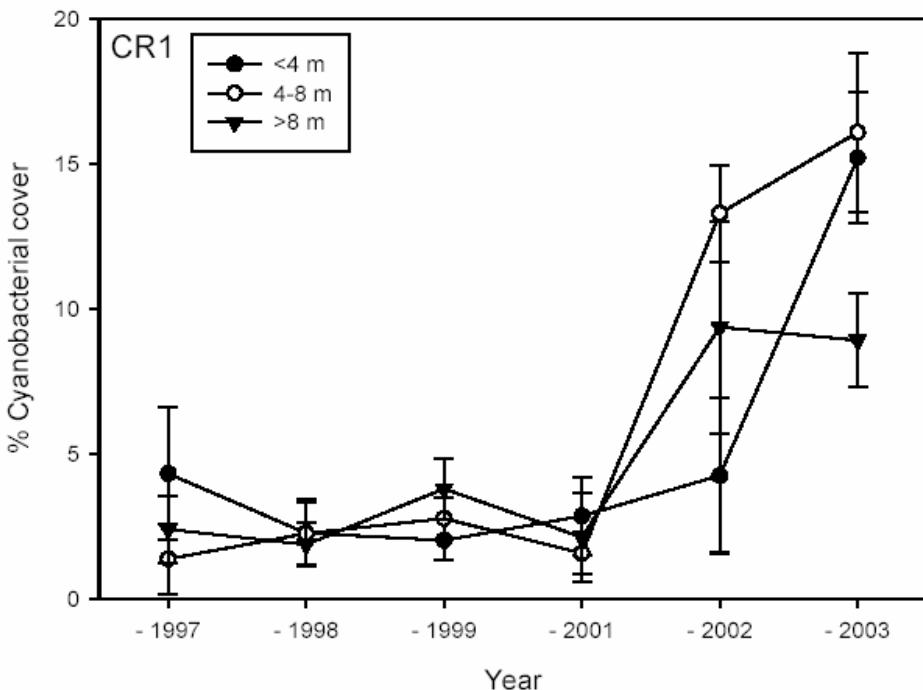
# Algae are taking over reefs!



- 104 to 1,423% increase in % macroalgal cover.

FIGURE 9. Change in the % of macroalgal cover at CR1 (mean $\pm$ one standard error).

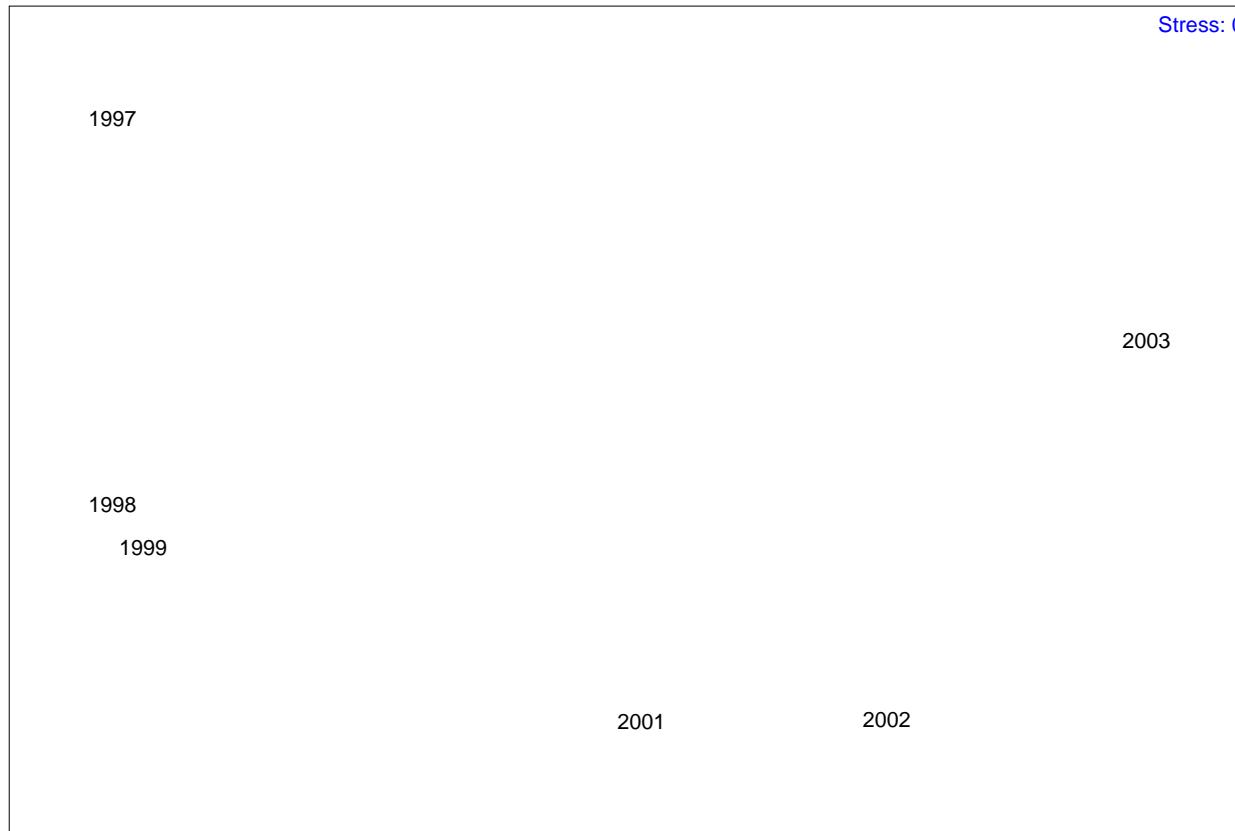
# Cyanobacteria are blooming!



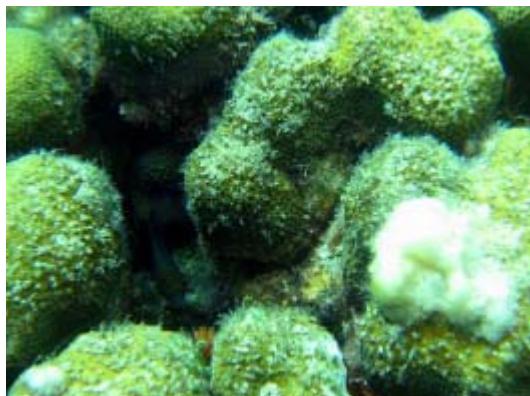
- 161 to 1,370% increase in % cyanobacterial cover.

FIGURE 11. Change in the % of cyanobacterial cover at CR1 (mean $\pm$ one standard error).

# Phase shift through time!



# A sort of “natural” mortality factors



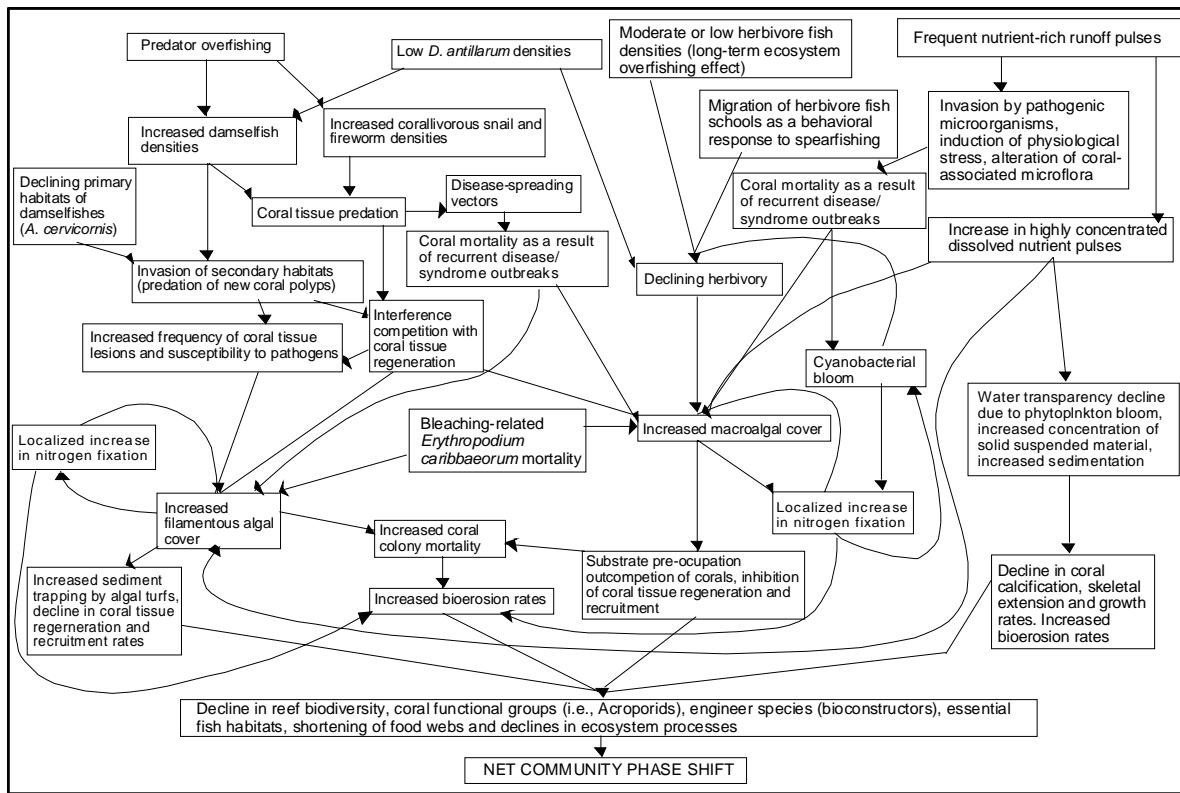
# Another bunch of human factors



- Water quality degradation associated to nutrient and sediment runoff pulses.



# Coral Reef Ecological Mess Model!



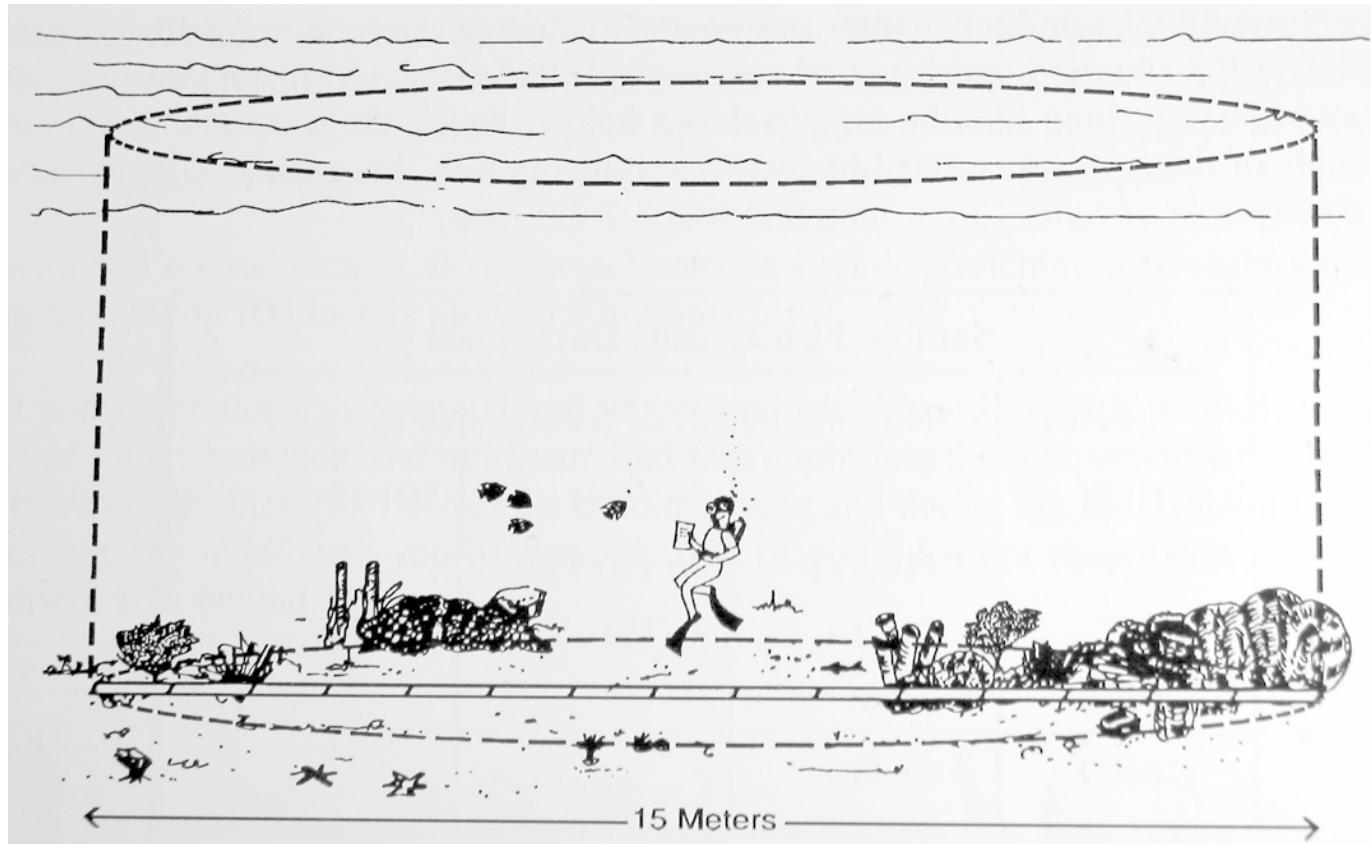
Oh, oh!!!!  
What the heck!



## Case Study #3

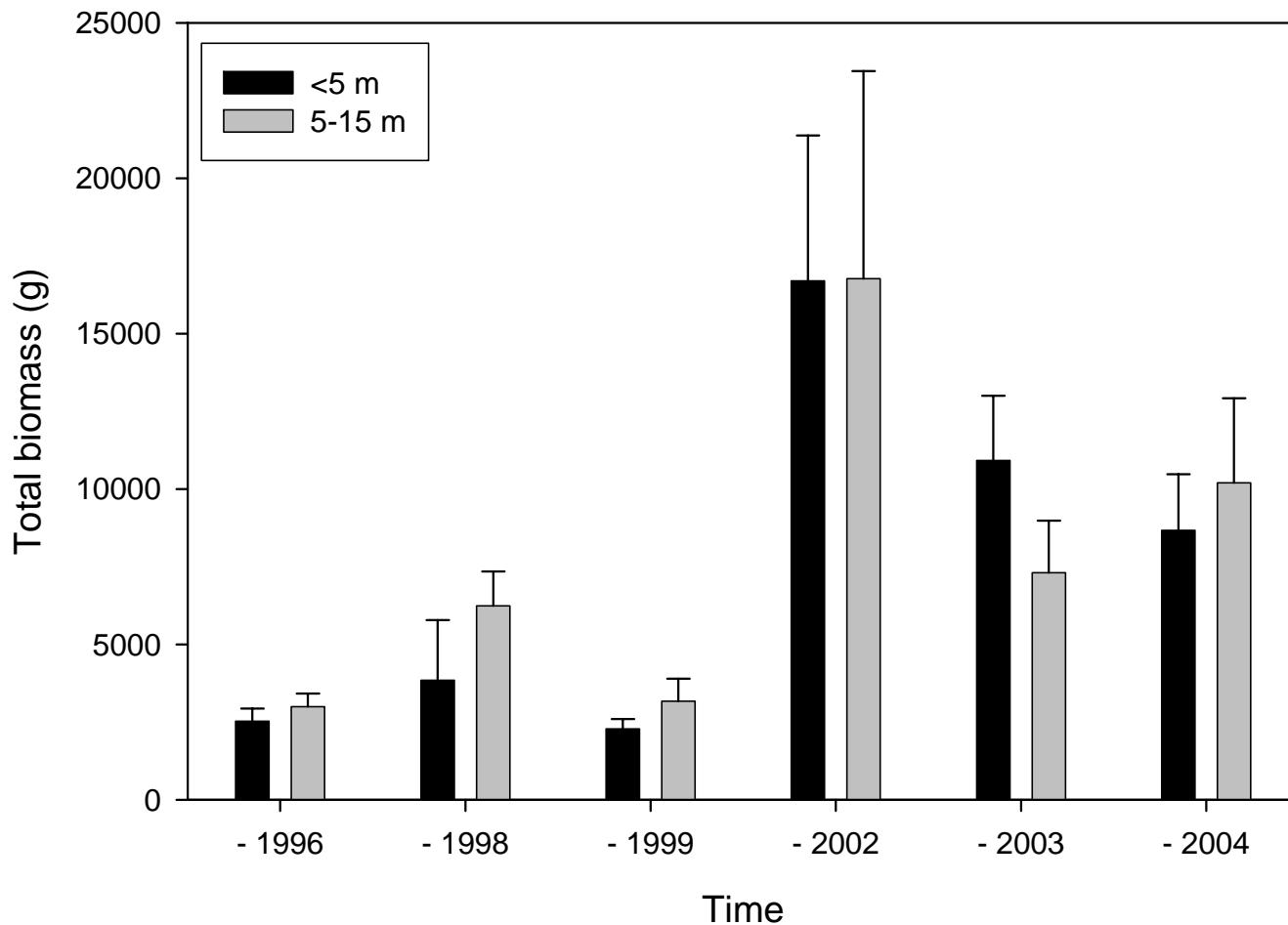
- Document spatial and temporal variation patterns in the structure of coral reef fish communities within the Luis Pena Channel No-Take Natural Reserve, Culebra, PR.

# Stationary visual censuses

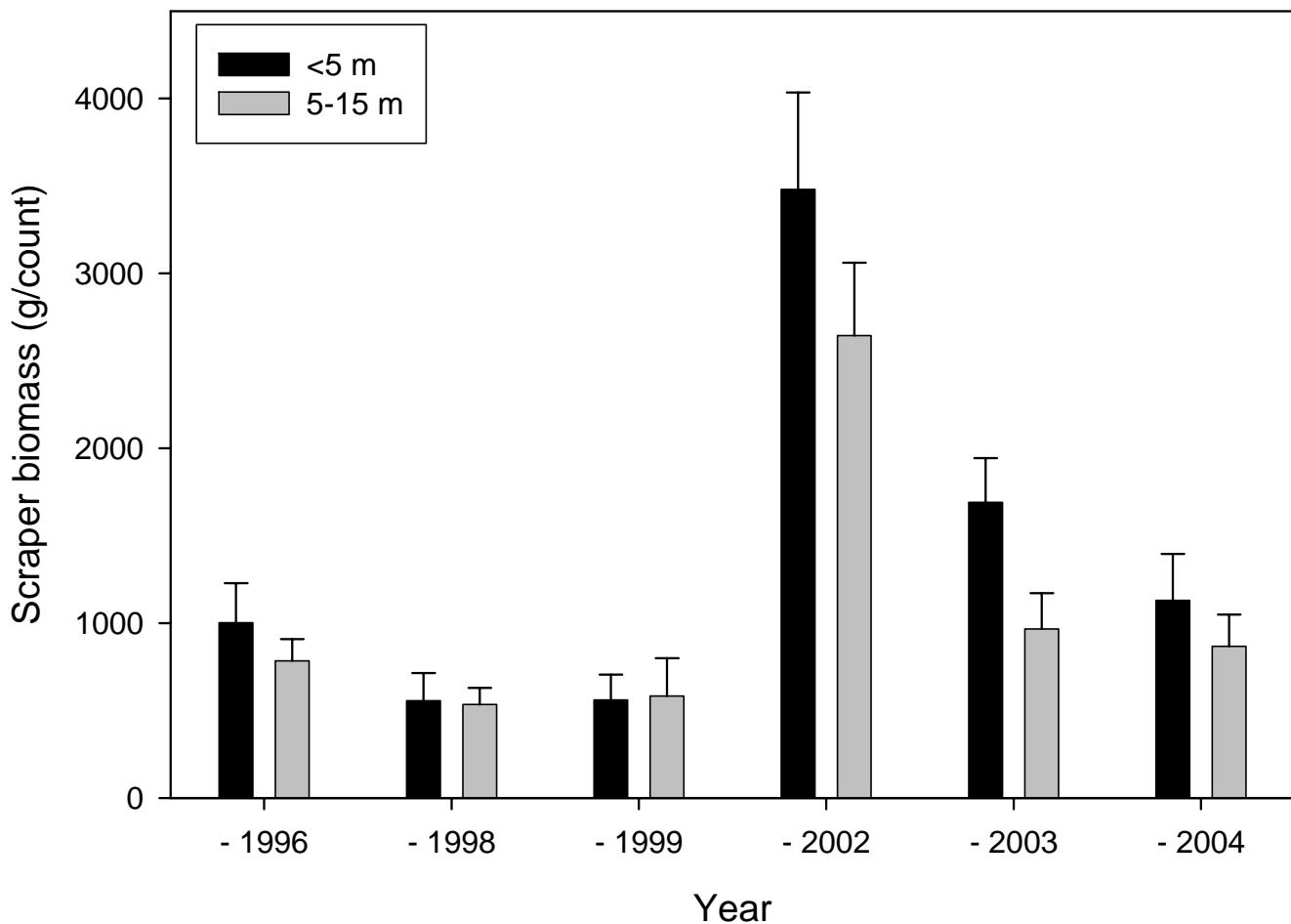


(Bohnsack & Bannerot, 1986)

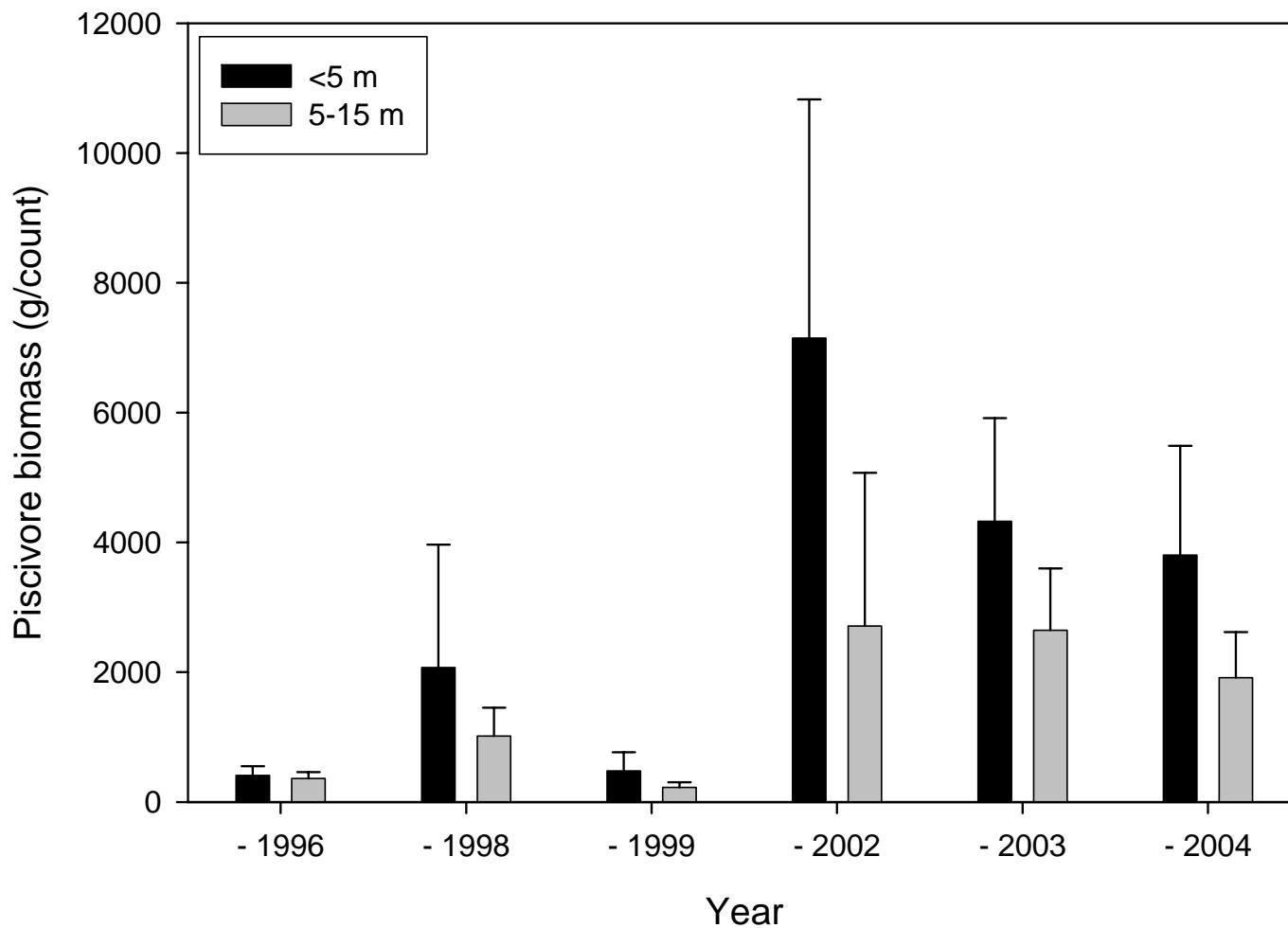
# Core: Total biomass



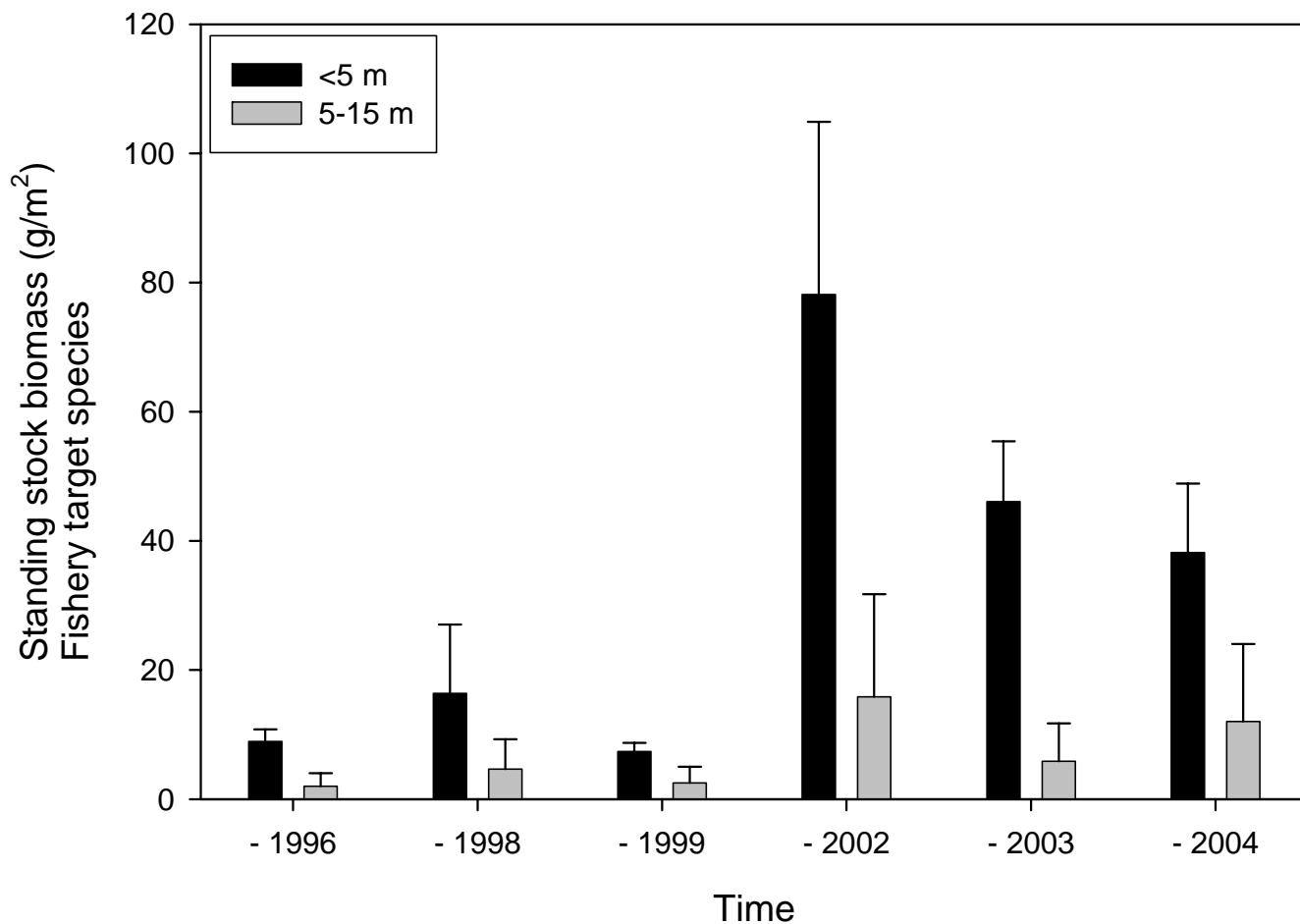
# Core: Scraper herbivore biomass



# Core: Piscivore biomass



# Core: Fishery target species SSB



# ANOSIM core area (1996-2004)

| Factors            | Global R | Significance |
|--------------------|----------|--------------|
| <i>Global test</i> |          |              |
| Year               | 0.600    | 0.2%         |
| Depth              | -0.013   | 42.9% NS     |
| Year x Depth       | 0.065    | 0.2%         |

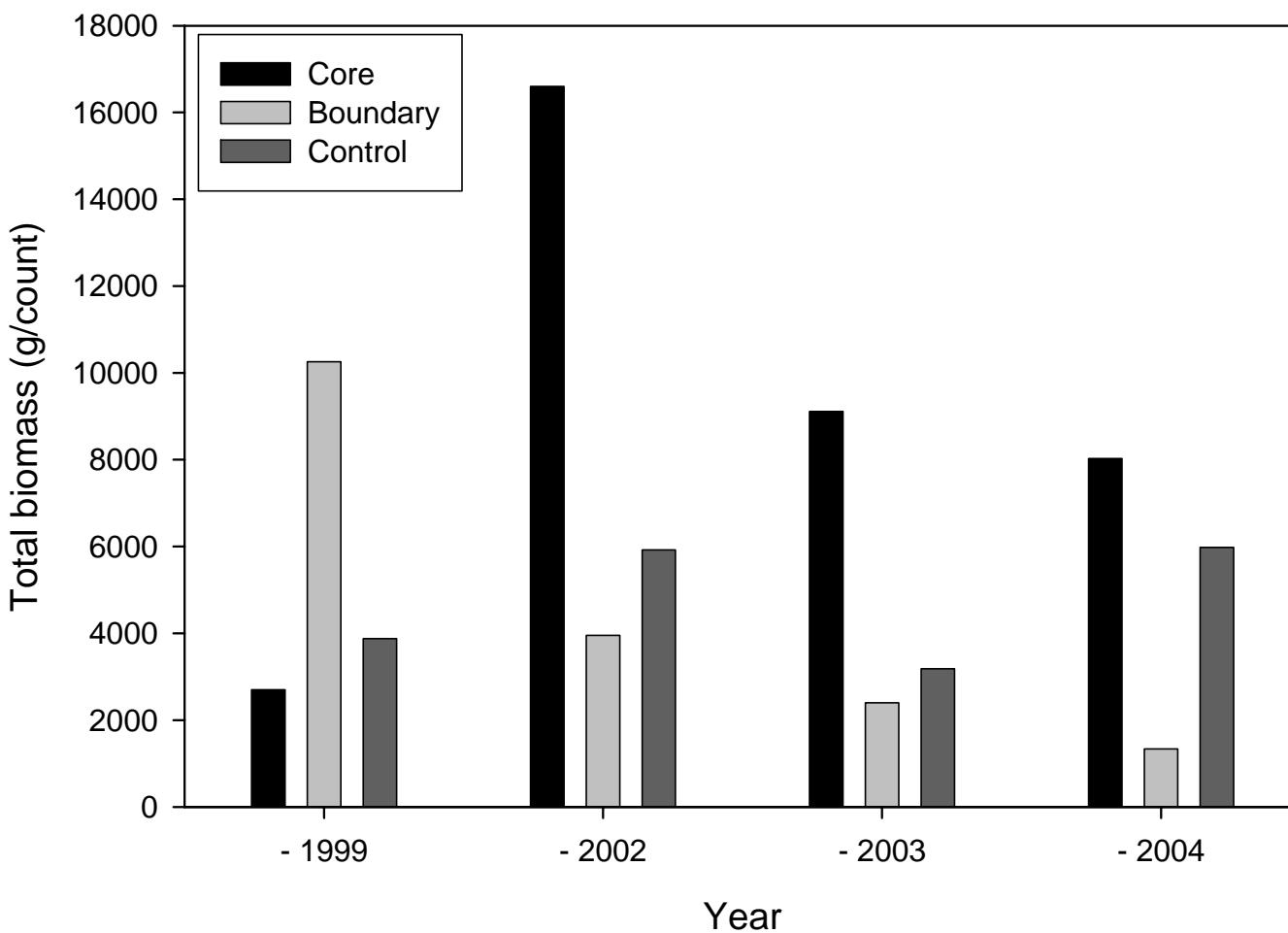
# ANOSIM core area (1996-2004)

| Factors              | Global R | Significance |
|----------------------|----------|--------------|
| <i>Pairwise test</i> |          |              |
| 1996 vs. 1998        | 0.014    | 31.0% NS     |
| 1996 vs. 1999        | 0.056    | 15.8% NS     |
| 1996 vs. 2002        | 0.068    | 4.1%         |
| 1996 vs. 2003        | 0.122    | 1.6%         |
| 1996 vs. 2004        | -0.001   | 46.8% NS     |
| 1999 vs. 2002        | 0.159    | 0.7%         |
| 1999 vs. 2003        | 0.221    | 0.1%         |
| 1999 vs. 2004        | 0.098    | 4.0%         |

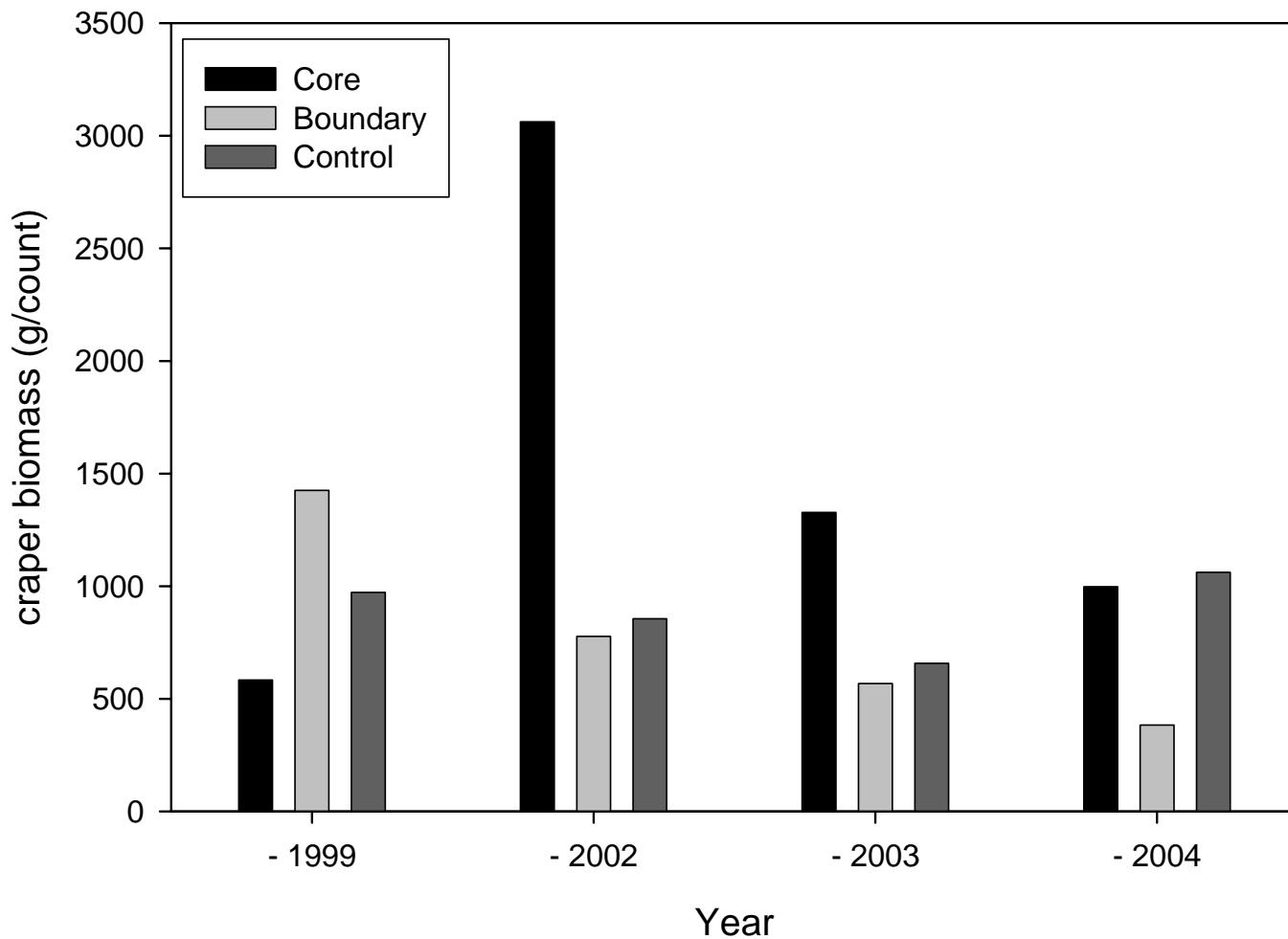
# What about spatial effects?



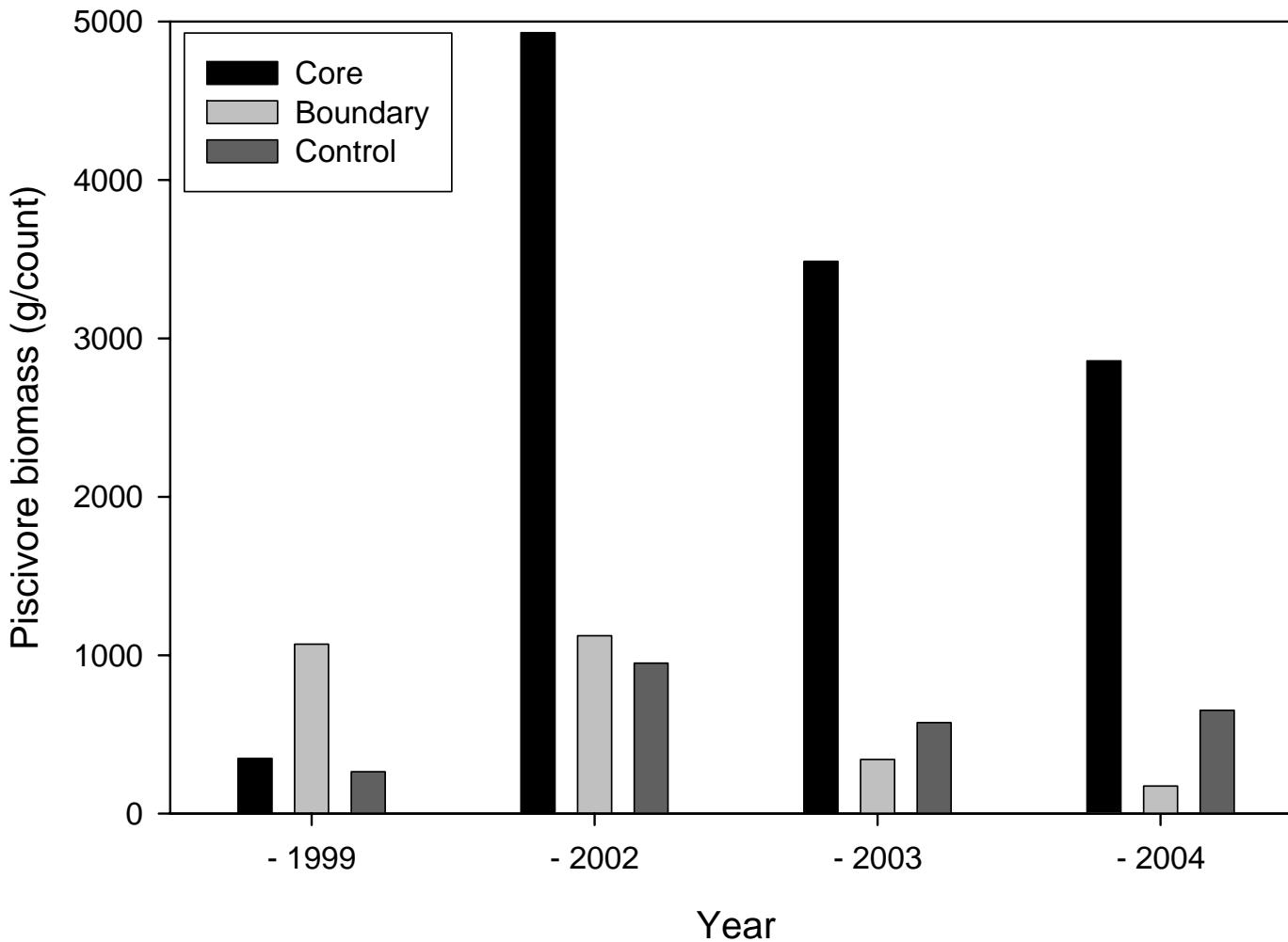
# Total biomass



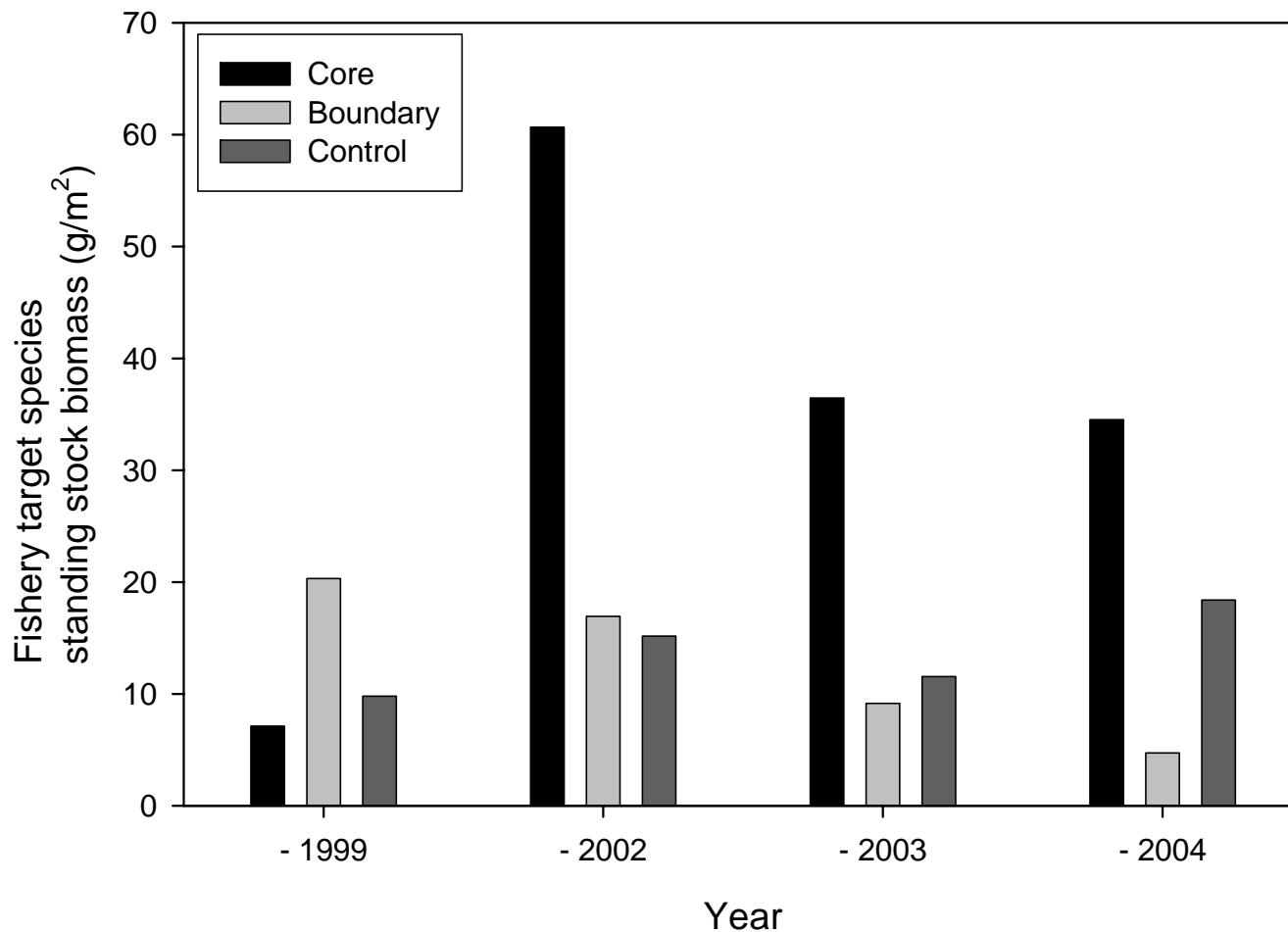
# Scraper herbivore biomass



# Piscivore biomass



# Fishery target species SSB



# ANOSIM Site x Year x Depth

| Factors            | Global R | Significance |
|--------------------|----------|--------------|
| <i>Global test</i> |          |              |
| Site               | 0.402    | 0.0%         |
| Year               | 0.079    | 11.9% NS     |
| Depth              | 0.004    | 40.0% NS     |
| Site x Year        | 0.403    | 0.9%         |
| Site x Depth       | 0.382    | 0.0%         |
| Year x Depth       | -0.073   | 77.4% NS     |

# Summary remarks

- CCRI-CRLTEMP aimed at measuring multiple coral reef benthic and fish community variables.
- Expand existing efforts to produce important baseline information regarding fish communities applicable to future model analysis.

# Summary remarks

- Provide a useful data bank and recommendations to State and Federal managers and decision-makers.
- Sampling design can be applied to test different hypotheses.
- Have information accessible to the general public.

**Thanks!**

**Any questions  
for Dad???**

